

Chromosomal Variability in a Nearctic Lycaenid Butterfly, *Philotes sonorensis*

(Lepidoptera: Lycaenidae)

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Variable chromosome number has been reported in many plants and animals. Aside from polyploidy, it is clear that chromosomal loss, Robertsonian rearrangement including centric fusion, and supernumerary chromosomes represent the common modes of change in chromosome number in groups as diverse as the flowering plants (Lewis, 1970), grasshoppers (Kayano *et al.*, 1970; White *et al.*, 1964), fish (Ohno *et al.*, 1965), lizards (Gorman and Atkins, 1967; Gorman *et al.*, 1968), white-throated sparrows (*Zonotrichia*) (Thornycroft, 1966), and mammals (Patton, 1969; Wahrman *et al.*, 1969). In groups with holokinetic chromosomes (e.g., butterflies and moths), fragmentation has been hypothesized as the chief factor leading to diversity of chromosome number (Emmel, 1972; Emmel and Trew, 1973). We report here extraordinary intraindividual as well as intrapopulation variability in butterfly karyotype, apparently resulting from chromosomal fragmentation at spermatogenesis.

MATERIAL AND METHODS.—The small lycaenid butterfly *Philotes sonorensis* Felder & Felder is found in scattered colonies in lowland areas of California, frequently in seasonally dry foothill canyons. It feeds on *Dudleya* (Crassulaceae) in the larval stages and flies as an adult in early spring. Samples of testes fixed in 3:1 absolute ethyl alcohol : glacial acetic acid were taken in 1970 and 1971 in three populations in Placer, El Dorado, and Stanislaus counties (43, 7, and 1 male specimens, respectively) and airmailed to the University of Florida for analysis. The testes were stained with lacto-aceto-orcin, squashed, observed and photographed under brightfield and phase (Emmel, 1969).

CYTOLOGICAL OBSERVATIONS AND DISCUSSION

In testes with dividing cells, meiosis appeared regular with pairing observed for all chromosomes (no univalents). One or more bivalents per karyotype were often composed of two smaller fragments synapsing with one large homologue in a tripartite bivalent (Fig. 1). Interestingly, Suomalainen (1969) has previously observed tripartite bivalents



FIG. 1. Pairing of apparent fragments with homologous chromosome in *Philotes sonorensis*. (a) Metaphase I, tripartite bivalent; (b) orientation of triple chromatid on spindle in late metaphase I. Redrawn from photographs; approx. 7200 $\times$ and 3600 $\times$.

(but no chiasmata) in females of the pyralid moth *Witlesia murana* Curt., indicating that fragmentation of moth chromosomes also occurs in nature.

Chromosome numbers ranging from $n = 17$ to 44 were found in populations surveyed (Fig. 2), with the modal number being 22 in the Placer County populations, 23 in the El Dorado County population, and 19 in the single male from the Stanislaus County population. Of the largest sample, the 13 Placer County males with clearly observable dividing cells, 7 (54 per cent) had multiple karyotypes. Four had $n = 22$ and 24 cells, and one had numerous meiotic cells ranging from $n = 22$ to 31. This great intraindividual variability was also found in the other sampled populations (Table 1). Cells with the higher chromosome number had smaller chromosomes in all cases.

Lesse (1960, 1969) found great chromosomal variability in populations of species of the Palearctic lycaenid butterfly genera *Lysandra* and *Agrodiaetus*, but until now there was no indication of its presence in any Nearctic butterflies. In the few Nearctic lycaenids surveyed to date (Maeki and Remington, 1961), the haploid number tends to be 24, with no intraindividual or intraspecies variation.

The selective significance of numerical chromosomal variability of this type would seem to lie first in the promotion of flexibility in the genotype's ability to respond to variable environment conditions. Unpublished observations we have made on the cytogenetics of other butterfly species demonstrate a very low chiasma frequency (usually two chiasmata per bivalent) in spermatogenesis and Suomalainen (1969) has previously reported a lack of chiasmata in oogenesis in Lepidoptera. The restriction on genetic exchange through crossing over would promote a low recombination index (Darlington, 1939) in Lepidoptera unless other factors were operating. It is clear that the high chromosome number (modal number being about $n = 31$) in moths and butterflies

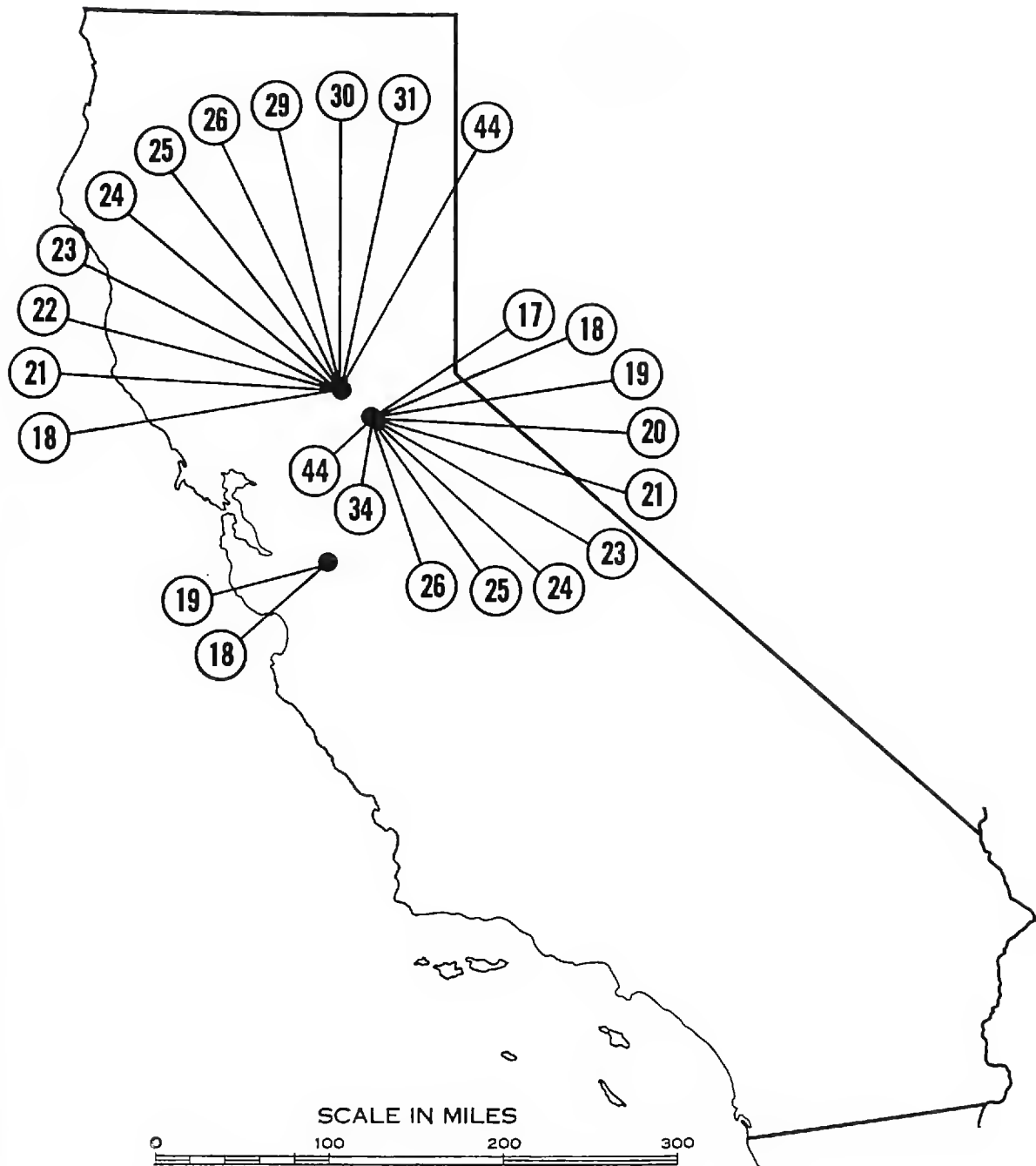


FIG. 2. The geographic relationships of three *Philotes sonorensis* populations in the state of California, showing variability in haploid number (n) of chromosomes found in males of each population. From north to south: Placer County (3–4 mi. N.E. of Auburn along Middle Fork of American River, 21 February 1970 and 13–14 February 1971); El Dorado County (4 mi. N. of Placerville on California Highway 193 at South Fork of the American River, 21 February 1970); Stanislaus County (18 mi. W. of Interstate Highway 5, Del Puerto Canyon, 7 March 1970).

as a group would compensate for this trend. The observations reported here offer evidence that fragmentation of butterfly chromosomes does occur in nature and that the holokinetic nature of the lepidopteran chromosome allows successful diakinesis in such cases.

The data from the present study and from Lesse (1960, 1969) also provide evidence for the suggestion that lepidopteran species in marginal

TABLE 1. Multiple Genotypes in Male Individuals of Three California Populations of *Philotes sonorensis* (bold-face type indicates median chromosome number for population sample).

Population ¹	No. of individuals with cells having chromosome number (<i>n</i>) of															Total No. Cells Counted (Individuals)
	17	18	19	20	21	22	23	24	25	26	29	30	31	34	44	
Placer County		1			3	10	2	2	1	1	1	1	1		4	50 (13)
El Dorado County	1	1	1	1	1		1	1	1	1				1	1	99 (4)
Stanislaus County		1	1													47 (1)

¹ See Fig. 1 legend for exact location of population. All counts (including *n* = 44) verified in Meiosis I (usually metaphase I) where chromosomes were still paired.

habitats or habitats with high environmental stress, such as *Philotes* in the dry foothill areas of California and *Lysandra* in certain areas of Spain, may often exhibit fragmentation of their chromosomes, promoting increased genetic flexibility. Such increased variability of supernumerary chromosomes has been found in marginal weedy populations of the plant *Claytonia virginica* L. (Lewis *et al.*, 1971), where bivalents form normally and meiosis is not upset. (The cytogenetics of this situation are not completely understood as yet.) Because of the holokinetic nature of lepidopteran chromosomes, however, their fission products can successfully synapse and segregate at meiosis. It would be predicted that such dramatic reassortment of the genotype through fragmentation should occur in other stress situations, as in rapid evolution of phenotypically polymorphic mimetic systems in Lepidoptera. Evidence for numerical polymorphism is accumulating for the genus *Heliconius*, especially *H. doris* (L.), which commonly participates in mimicry complexes in South and Central America (Emmel, in preparation).

A possible coevolutionary feature of this chromosomal variability in *Philotes* is the polyploidy ($n = 17, 34, 51, 68$) found in the two *Dudleya* subgenera that *P. sonorensis* larvae use as hosts (Moran, 1951; Moran and Uhl, 1952; Uhl and Moran, 1953). Hybridization between host species is common. The small seeds of *Dudleya* are viable only a short time and are not adapted for long-range dispersal; hence the host colonies are usually quite isolated. Adult *Philotes sonorensis* have been shown to have a restricted home range in an extensive mark-recapture study (Keller *et al.*, 1966; Mattoni and Seiger, 1963). It would thus appear that the butterfly is closely linked to its foodplant and some of the same factors that make polyploidy of selective value in *Dudleya* may be preserving gains and losses of chromosomes in *Philotes*.

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SCIENTIFIC NOTE

Notes on the Distribution and Ecology of *Scaphinotus bilobus* (Coleoptera:Carabidae).—According to Lindroth (1961. *Opusc. Entomol. Suppl.*, 20: 1-200), "the species is rare and its demands little known." This species is mainly northeastern and it is distributed south to Illinois, Missouri, Ohio, and Catskill Mountains, N.Y., west to Nebraska. In Canada, Lindroth records this ground beetle from Nova Scotia, Québec (a single locality), Ontario and Manitoba.

The species is not uncommon in southern Québec (south of 50° N Lat.). In the locality records, the following abbreviations were used to indicate the collections in which the specimens are located: AL—André Larochelle Collection, Rigaud; CC—Claude Chantal Collection, Québec; CH—Cercle Harricana Collection, Amos; JCA—Jean-Charles Aubé Collection, Québec; JPL—Jean-Paul Laplante Collection, Sainte-Foy; LEM—Lyman Entomological Museum, Sainte-Anne-de-Bellevue; LRF—Laboratoire de Recherches Forestières Collection, Sainte-Foy; UM—Université de Montréal Collection, Montréal. The distribution of *Scaphinotus bilobus* Say in Québec is: Abitibi Co., Amos, 13 May 1962 (1, CH); Chapais, 11 August 1972 (2, AL); Chibougamau, 23 September 1968 (2, CC) and 12 August 1972 (1, AL); Lac Chicobi, 21 June 1968 (2, AL); La Ferme, 26 May 1963 (1, UM); Lebel-sur-Quévillon, 16 July 1968 (3, AL); Matagami, 20 June 1968 (3, AL); Saint-Mathieu, 1 July 1964 (1, CH); Senneterre, 12 July 1968 (1, AL); Val-d'Or, 11 July 1968 (2, AL). Champlain Co., Lac Normand, 27 August 1969 (2, CC). Charlevoix-Est Co., Baie-Sainte-Catherine, 28 June 1969 and 1970 (10, AL; 2, CC). Charlevoix-Ouest Co., Baie-Saint-Paul, 13 September 1969 (1, CC). Frontenac Co., Woburn, 2 September 1955 (2, JPL). Lotbinière Co., Saint-Sylvestre, 14 July 1967 (1, JCA). Matane Co., Métis-sur-Mer, 18 August 1889 (2, LEM). Montmorency No. 1 Co., Grand Lac Jacques-Cartier, 31 August 1968 (1, CC). Saguenay Co., Tadoussac, 14 June 1971 (2, AL). Saint-Maurice Co., Lac Caousacouta, 21 June 1965 (2, JPL), 17 July 1968 (1, LRF), 22 July 1965 (1, LRF) and 23 September 1965 (4, JPL; Lindroth, 1969. *Opusc. Entomol. Suppl.* 34: 945-1192). Témiscamingue Co., Tabaret, 5 May 1968 (1, AL).

This species is confined to shaded, rather moist places, especially coniferous and mixed forests, on banks of lakes and rivers. During the day hiding under dead leaves and logs, it often invades the river banks, peat-bogs and clearings in the night in search of snails. Associated ground beetles include: *Agonum retractum* LeConte, *Calathus ingratus* Dejean, *Pterostichus adstrictus* Eschscholtz, *Pterostichus coracinus* Newman, *Pterostichus punctatissimus* Randall and *Sphaeroderus nitidicollis brevoorti* LeConte.—ANDRÉ LAROCHELLE, *Collège Bourget, C. P. 1000, Rigaud, Québec*.